penetrate the remainder of the hide while not having enough energy to successfully penetrate the muscle.

Finally, while this entire discussion has focused on perforator advantages for an intramuscular injection, both veterinary and human immunologists have cited experimental evidence indicating that injections into the dermis may be many times more potent than that of the IM or subcutaneous regions, so much so, in fact, that greatly reduced volumes of the injectant may be possible. If continued research in this regard leads to a recommendation that certain injections be given in the dermis, the perforator concept is remarkably effective for this application as well, and actually provides additional advantages over that of the needle and syringe. To assure a perforator intradermal injection, one must simply shorten the length X so that it penetrates the outer layer while at the same time falling short of the subcutaneous space. In addition, if the pressure is reduced to the appropriate level, experimental work by the inventor on a freshly euthanized cow has shown that all of the injectant will remain in the dermis, with none at the surface, while also spreading the injectant over a much wider radius than that experienced with the pooling effect of the prior art needle and syringe. As with the IM or subcutaneous injection, the increased area and volume covered by the injectant will provide an increasingly rapid and effective pick-up by the immune system.

The range of thicknesses of the skin, hide or dermis for humans and a variety of animals is known, and are set forth below:

humans: 1.0 mm–12.7 mm
cattle: 4 mm–8 mm
goats: 1 mm–5 mm
dogs: 1 mm (minimum thickness)
horses: 1 mm–5 mm
pigs: 2.7 mm–4.7 mm

Therefore, for dermal injections, the perforator should be less than 1 mm for any animal (or person) such as humans, goats, dogs and horses at their minimum skin thickness, less than 2.7 mm for animals such as pigs, at their minimum skin thickness, and less than 4 mm for animals such as cattle at their minimum skin thickness. Likewise, the perforator could be longer for injecting into humans or other animals at thicker parts of their skin but less than 12.7 mm (humans), 5 mm (animals such as goats and horses), 4.7 mm (animals such as pigs) and 8 mm (animals such as cattle).

FIG. **9D** illustrates the jet stream coming from a conventional prior art flat injection orifice. An injection assembly **896** includes capsule **871** with housing **872** and plunger **874**, and a flat jet orifice **897**. When plunger **874** is depressed, a jet stream **898** is emitted, and beginning from the outer surface of the hide **860**, the tough, hairy and often dirty conditions immediately often cause degradation of stream **898** so that a high percentage of the injectant remains on the outside, with very little, and in many cases, none of the injectant reaching subcutaneous space **862** or muscle **864**, resulting in a much less effective injection, even if a dermal injection was intended.

FIG. **9E** is an alternate embodiment of the invention showing perforator **882** from FIGS. **9B** and **9C**, but with a different orifice. In this case, a high quality, smaller diameter orifice **899** is located at the entrance end or port of perforator **882**. When the jet injection is initiated, it will travel down the middle of perforator **882** without touching the walls and before encountering any of the animals hide or flesh. The very high quality, high coherency of such a flow pattern **900** will allow for much deeper muscle penetration with even less of the injectant being left behind in the dermis **860** or subcutaneous layer **862** if the objective is an intramuscular injection.

FIG. **9F** shows injection system **880** with a high quality orifice **902** connected to the injection chamber of housing **872**, and having an externally threaded connector ring **904** affixed thereto. A perforator **906**, similar to perforator **882** but having an internally threaded entrance end or port **908** for engagement with the threads on connector ring **904**. The threaded connection between connector ring **904** and perforator **906** provides for an easy change of perforator **906** by simply unscrewing perforator **906**. Other fast connect-disconnect devices can be used as well. The system emits jet stream **900** as noted with respect to FIG. **9E**.

System **800** in FIG. **9G** is similar to that in FIG. **9E**, except that the high quality orifice **899** is located at the exit end of perforator **882**.

The injection systems according to the invention, such as shown for example in FIGS. **9B**, **9E**, **9F** and **9G** have generally flat front faces through which the perforator is extendable. The flat face helps prevent the hair and unsanitary material (such as that stuck on the hair) from being urged towards the injection site. The larger cross sectional area of contact around the injection site helps avoid the urging of tissue movement. The face need not be absolutely planar, but could have slight curves, a rough surface, indentations or the like, while preventing the urging of the foregoing movement.

Finally, FIG. **9H** illustrates an adaptation derived from the perforator concept. In this embodiment, small diameter exit tube **907** extends about 2 to 4 mm from injector housing **871** and is configured with a non-sharpened, flat ended output. This diagram is not shown to scale and is drawn primarily for illustrative purposes. With this embodiment, there is no initial perforation, but it was found that the short protrusion will move aside any hair and both stretch and provide a detent at an injection site **909** when surface contact is made. Significant improvements in jet penetration is realized, while at the same time reducing the amount of injectant left at the surface as opposed to that of the prior art flat orifice of FIG. **9D**. Benefits are found for human injections, for thinner hides of young calves and for other thin-skinned animal applications such as cats, dogs, fowl, etc.

The illustrative embodiments of our invention which are disclosed herein are but representative of our invention and many changes in form and function can be made without departing from the spirit and scope of our invention.

What is claimed is:

1. Apparatus for injecting fluid into a desired section of a body having an outer dermis and an inner region including at least a subcutaneous region and for some parts of the body, a muscular region, said apparatus comprising:

a fluid supplying device for supplying fluids at values of pressure and velocity of sufficient magnitude to generate a jet stream, and to inject a substantial amount of the fluid into a selected one of the outer dermis and the inner region; and

a perforator for making a perforation and entering the dermis of the body, said perforator comprised of an elongated tubular member having a first end connected to said fluid supplying device and an opposed sharp second end for perforating the body and dispensing the jet stream of fluid into the perforation, said perforator having an effective length of less than 12.7 mm, said effective length preventing said perforator from perforating the muscular region;

said fluid supplying device having a generally flat face through which said perforator is extendable.

2. Apparatus according to claim 1 wherein said perforator has a longitudinal axis extending from said first end up to said second end, and said second end has a central axis slanted relative to the longitudinal axis of said perforator for enabling said second end to penetrate the dermis and create an anchor point to establish and maintain the penetration position of said second end, and maintain an effective fluid flow of the jet stream even if there is movement of the body being injected.

3. Apparatus according to 2 wherein said second end has a surgically sharp end for piercing the dermis.

4. Apparatus according to claim 1, and further comprising:

orifice means positioned in said perforator for generating a coherent stream for flow through said exit portion.

5. Apparatus according to claim 1, wherein said perforator has an effective length of less than 4 mm.

6. Apparatus according to claim 1, wherein said perforator has an effective length of less than 1.5 mm.

7. Apparatus according to claim 1, wherein said perforator has an effective length of less than 9.5 mm.

8. Apparatus according to claim 1, wherein said perforator has an effective length of less than 3.1 mm.

9. Apparatus according to claim 1, wherein said perforator has an effective length of less than 8 mm.

10. Apparatus according to claim 1, wherein said perforator has an effective length of less than 5 mm.

11. Apparatus according to claim 1, wherein said perforator has an effective length of less than 1 mm.

12. Apparatus according to claim 1, wherein said perforator has an effective length of less than 4.7 mm.

13. Apparatus according to claim 1, wherein said perforator has an effective length of less than 2.7 mm.

14. Apparatus according to claim 1, wherein said perforator has an effective length of less than 4.2 mm.

15. Apparatus according to claim 1, wherein said perforator has an effective length of less than 3.6 mm.

16. Apparatus according to claim 1 wherein said perforator is removable and replaceable with another perforator.

17. Apparatus according to claim 1 and further including protective containment means for protectively containing said perforator before and after said perforator makes a perforation and enters the dermis of the body.

18. Apparatus for injecting fluid into a desired section of a body having a dermis and an inner region including at least a subcutaneous region, and for some parts of the body a muscular region, said apparatus comprising:

an electro-mechanical, spring energized fluid supplying device for supplying fluids at values of pressure and velocity of sufficient magnitude to generate a jet stream, and to inject a substantial amount of the fluid into a selected one of the outer dermis and the inner region; and

a perforator for making a perforation and entering the dermis of the body, said perforator comprised of an elongated tubular member having a first end connected to said fluid supplying device and an opposed sharp second end for perforating the body and dispensing the jet stream of fluid into the perforation, said perforator having an effective length of less than 12.7 mm, said effective length preventing said perforator from perforating the muscular region;

said fluid supplying device having a generally flat face through said perforator is extendable.

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